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# Human Factors Contributing to Groundfall Accidents in Underground Coal Mines: Workers' Views

By Robert H. Peters and William J. Wiehagen



UNITED STATES DEPARTMENT OF THE INTERIOR



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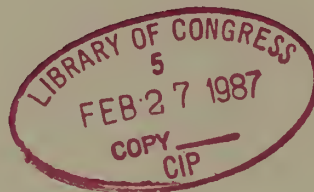


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## UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

h	hour	pct	percent
min	minute	yr	year



# HUMAN FACTORS CONTRIBUTING TO GROUND FALL ACCIDENTS IN UNDERGROUND COAL MINES: WORKERS' VIEWS

By Robert H. Peters<sup>1</sup> and William J. Wiehagen<sup>2</sup>

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## ABSTRACT

This report presents findings from a Bureau of Mines study on barriers that may prevent miners from correcting and avoiding groundfall hazards. Such barriers stem from four basic types of problems: (1) inability to recognize groundfall hazards, (2) inability to correct groundfall hazards, (3) lack of motivation to search for groundfall hazards, and (4) lack of motivation to correct groundfall hazards. Data are presented that summarize the views of miners, section supervisors, and mine inspectors about the contribution of these barriers to groundfall accidents and what they think should be done to reduce the frequency of injuries sustained by falls of roof and rib. The report also includes a summary of miners' responses concerning their recent experiences with groundfall accidents, along with industrywide statistics on accidents and injuries caused by ground falls in underground coal mines.

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## INTRODUCTION

In many underground coal mines, the economic costs associated with falls of roof and rib are a substantial proportion of the total costs of operating the mine. During the 5-yr period, 1980-84, 16,352 groundfall accidents were reported to the Mine Safety and Health Administration (MSHA).

These accidents often require that labor, supplies, and equipment be diverted from coal production and used for cleanup, recovery and repair of mine equipment, and resupport of the mine roof. The costs of these activities are quite substantial. But of even greater significance are the financial and intangible losses and the emotional anguish suffered by the families of miners who have been killed or seriously disabled by groundfalls. During 1980-84, groundfall accidents claimed the lives of 181 coal miners and caused 5,323 nonfatal injuries. According to the Accident Cost Indicator Model, the direct cost of these fatalities and injuries exceeded \$200 million.<sup>3</sup>

Although the number of coal miners killed by groundfalls has greatly declined since the first half of this century, groundfall fatalities continue to occur with alarming frequency and are the most common cause of accidental death among underground coal miners. During 1980-84, groundfalls claimed the lives of underground coal miners at an average rate of one fatality every 10 calendar days. During the same period, the average number of miners who suffered a lost-time injury caused by a groundfall accident was 914.2 per year, and the average number of scheduled workdays lost as a result of these injuries was 35.3 days. Clearly, the need to further reduce the number of miners being injured and killed by groundfall accidents is great.

The Bureau of Mines performed the research described in this report to (1) better define the types of barriers that

prevent miners from correcting or avoiding groundfall hazards, (2) provide a data base and direction for future research, and (3) identify promising approaches for preventing groundfall accidents. Interviews were conducted with (1) various personnel from three underground coal companies (nine sites) and (2) MSHA coal mine roof and rib inspectors. Interviewers used a structured interview guide (which is reproduced in the appendix to this report).

The long-range goal of this research program is to find effective strategies and methods for making miners willing and able to prevent or avoid groundfalls. The final step in the program will be to empirically test hypotheses such as: The use of strategy X leads to a significantly lower probability of groundfall accidents; or, the use of strategy X leads to a significantly lower probability of groundfall accidents than strategy Y under conditions A, B, and C.

One of the initial steps toward achieving this goal is to formulate hypotheses. In order to formulate good hypotheses about how to prevent groundfall accidents, it is important to understand why many groundfall accidents occur even though it may appear or actually be the case that miners could have prevented or avoided the groundfall. Researchers need to understand the sequence of events and the circumstances that lead to these accidents. They need to understand what the key variables and processes are. Unfortunately, researchers do not yet have a good understanding of these key variables and processes.

One of the best ways to develop such an understanding is to determine what those who work in mines understand and/or believe about the causes of groundfall accidents. Therefore, the purpose of this study is *not* to collect data that can be statistically tested to determine the effectiveness of strategies for preventing groundfall accidents. The purpose of the data collected for this study is to improve researchers' and mine operators' understanding of what those who work underground believe about the causes of groundfall accidents. It is hoped that this information will help future researchers formulate intelligent hypotheses about what strategies would be effective in preventing groundfall accidents.

<sup>3</sup>DiCanio, D. G., A. H. Nakata, D. Colvert, and E. LaVeque. Accident Cost Indicator Model to Estimate Costs to Industry and Society From Work-Related Injuries and Deaths in Underground Coal Mining (contract J0255031, FMC Corp.). Volume 3: Supporting Data. BuMines OFR 39(3)-77, 1976, 104 pp.; NTIS PB 264 440.

## BARRIERS TO MINERS' PREVENTION OF GROUNDFAH ACCIDENTS

Geological factors relevant to the inherent stability of the roof and rib influence the likelihood of a groundfall accident. Although geological history cannot be changed, there are several other factors that influence the probability of groundfall accidents over which people potentially have some control. This study focuses primarily on (1) assessing the measures *miners* can potentially take to avoid groundfall accidents and (2) gaining a better understanding of the types of barriers that prevent them from taking these measures.

Figure 1 presents a conceptual framework for addressing these barriers. The model assumes that in order for miners to do an effective job of preventing groundfall injuries, they must not only recognize the existence of the hazard but also be willing and able to take corrective action. Barriers can be differentiated on the basis of whether

they occur at the stage of hazard recognition or hazard correction, and on the basis of whether they are due to miners' lack of ability or lack of motivation. The primary causes for each of the four categories of barriers are discussed below.

### INABILITY TO RECOGNIZE GROUNDFAH HAZARDS

In order for miners to recognize a groundfall hazard, they must be able to detect it. Miners with poor eyesight or miners working in areas with insufficient illumination may be unable, for example, to detect cracks associated with dangerously loose roof or rib. Miners with hearing deficiencies, or those who work in areas with high noise levels, may

## Stage of barrier's occurrence

**Source of  
barrier**

**Recognition**

**Correction**

**Ability**

**Inability to  
recognize  
groundfall hazards**

**Inability to  
correct  
groundfall hazards**

**Motivation**

**Lack of motivation  
to search for  
groundfall hazards**

**Lack of motivation  
to correct  
groundfall hazards**

Figure 1.—Barriers to miners' prevention of groundfall accidents.

be unable to detect sounds that may accompany an impending groundfall. Some miners may be able to perceive the visual and auditory cues commonly associated with some groundfall hazards, but, due to a lack of experience or training, have not learned to relate these cues to the impending fall.

### **INABILITY TO CORRECT GROUND FALL HAZARDS**

In order for miners to prevent groundfall accidents, they must not only be able to recognize the hazard, they must also be able to take the necessary corrective actions. Miners must be properly trained to scale the roof, set temporary roof supports, and perform other ground control activities. In addition to having the ability to correct the problem, miners must also be provided with sufficient time and resources (tools and supplies) to take the appropriate action.

### **MOTIVATION TO SEARCH FOR GROUND FALL HAZARDS**

Unfortunately, groundfall hazards are not always located where they can be easily seen. It is therefore important that miners devote some extra effort to visually search for roof and rib hazards. One determinant of a miner's motivation to search for such hazards is his or her perception of the danger that groundfalls represent.

The greater a miner's fear of groundfalls and the greater the perceived probability of a groundfall occurring, the higher will be the motivation to search for hazardous roof and rib. Another determinant of a miner's motivation to search for such hazards is the extent to which management

encourages miners to prevent groundfall accidents. Miners will be more likely to search for hazardous rock conditions if their supervisor makes it clear that this is an important aspect of the job.

### **MOTIVATION TO CORRECT GROUND FALL HAZARDS**

Even if a groundfall hazard is recognized and the miner is able to correct it, the hazard will not be corrected unless the miner is sufficiently motivated to do so. A miner's motivation to correct groundfall hazards is influenced by many factors, including the two mentioned above: perceived danger and perceived importance to management. Perceptions of danger encompass both the perceived probability of a roof or rib failure as well as the perceived extent or degree of damage the fall could cause. Perceptions of the likelihood of a groundfall are derived from the miner's past experience with groundfalls and from cues associated with the stability of the rock being examined, such as the absence of adequate support or the presence of severe cracks.

Perceptions of the amount of damage the rock would cause if it fell are probably derived from exposure to the effects of past groundfalls and the location of the hazard in question. Hazardous roof and rib are less likely to be tolerated in areas where people and equipment are frequently traversed than if located in some remote area of the mine. Any bias in the direction of underestimating the likelihood that rock will fall or underestimating the amount of harm it would cause increases the chances of a groundfall injury because it lessens the miner's motivation to correct the hazard.

Miners are responsible for performing many types of activities and have a limited amount of time and energy with

which to get them done. This means that whether or not the miner corrects a recognized hazard will depend on the perceived importance of performing this type of activity versus a variety of other types of activities that the miner may simultaneously feel compelled to perform. As mentioned previously, the extent to which miners are motivated to maintain safe work conditions is largely determined by

management, especially the miner's immediate supervisor.

Obviously, there is a multitude of factors that contribute to the occurrence of groundfall accidents. This suggests that there is a multitude of approaches to the reduction of groundfall accidents, and that it is unlikely that any one approach will be a panacea.

## METHODS OF DATA COLLECTION

A sample of miners, section supervisors, and MSHA inspectors was asked to respond to a variety of questions in one-on-one interviews. Most of the questions were intended to determine if the people who work in underground coal mines consider the factors identified in the previous section to be important contributors to groundfall accidents. Other questions dealt with strategies for reducing the frequency of roof and rib fall accidents.

### SAMPLE

Data were collected from February 1984 to April 1985. A total of 143 employees from 3 underground coal mining companies located at 9 sites in Pennsylvania, Virginia, and Kentucky participated in the study. The three companies are referred to here as companies A, B, and C.

Company A owns two medium-size mines in southwestern Pennsylvania; data were collected from 52 employees at 1 of these 2 mines. Company B owns several small mines in western Virginia; data were collected from 44 employees at 4 of these mines. Company C owns several small mines in western Virginia and eastern Kentucky; data were collected from 47 employees at 4 of these mines. All mines in this study were using the room-and-pillar method of extraction and continuous mining machinery. No roof fall fatalities have occurred at any of these mines. Table 1 breaks down the total sample of mine employees by job title. The average length of time spent working as an underground coal miner was 10.5 yr. Of the 143 employees in the sample, 85 pct had some experience as a bolter or bolter helper. All 143 employees were working underground on a daily basis. The sample did not include cleaning plant personnel or other persons who work aboveground.

Data were also collected from nine MSHA coal mine roof and rib inspectors. The number of years these individuals had been inspecting mines primarily for roof and rib control ranged from 3 to 10 yr, with the average being 6.9 yr. Each of the inspectors had a sizable amount of underground

experience, both as miners and as Federal coal mine inspectors. These participants averaged 20.1 yr of underground experience before they became inspectors.

Table 1.—Breakdown of mine employees interviewed, by job title

	Number
Belt worker .....	2
Bridge worker .....	2
Continuous miner operator .....	16
Continuous miner operator helper .....	10
General inside laborer .....	10
Mechanic .....	11
Roof bolter .....	27
Roof bolter helper .....	10
Scoop operator .....	2
Section supervisor .....	14
Shuttlecar operator .....	25
Supply worker .....	2
Timber worker .....	5
Utility worker .....	5
Total .....	143

### INTERVIEWS

Data were collected using a structured interview guide. (See appendix.) Interviewers asked questions concerning the following issues: (1) recent experiences with roof falls, (2) why miners sometimes fail to do anything about potential roof hazards, (3) why miners sometimes walk beneath unsupported roof, and (4) the degree to which various changes would help miners avoid rock fall injuries. Participants were asked to respond to both open-ended and forced-choice questions.

All interviews with miners were conducted in private either at the miner's worksite or at a nearby company training facility. Interviews with MSHA inspectors were conducted at their offices. All participants were assured that their responses would be held in confidence and were told that their participation was completely voluntary. Interviews required approximately 30 min to complete.

## FINDINGS

This section presents participants' responses to all interview questions in the sections of the interview guide (appendix) titled "Nonresponse to Possible Roof Hazards," "Working Beneath Unsupported Roof," and "Techniques for Reducing Roof Fall Accidents." Responses to both open-ended and forced-choice questions are presented. For the forced-choice questions, simple frequencies of the response categories chosen to answer each question are given in tabular form. In these tabular listings, separate response distributions are given for (1) section supervisors, (2) bolters and bolter helpers, (3) MSHA inspectors, and (4) the total

sample of underground miners (including the section supervisors, but not the MSHA inspectors).

Because the numbers of individuals in the subgroups tended to be small (MSHA inspectors and supervisors especially), differences between the responses of people in these subgroups should not be looked upon as a strong indication that any substantial differences exist between the populations represented by the subgroups. At best, such differences should be viewed as weak evidence that the populations may differ.

## NONRESPONSE TO POSSIBLE ROOF HAZARDS

Each participant was initially asked to respond to an open-ended question on why miners sometimes do not take action to correct roof hazards. This question was followed by eight forced-choice questions.

### Open-Ended Questions

Participants were asked for their opinions about why miners sometimes neglect to correct hazardous roof conditions. The question was asked as follows:

At one time or another, most miners have seen areas of the roof that look like they may not be entirely safe, but for some reason, do not do anything about it. What are the major reasons why miners sometimes fail to do anything about potential roof hazards?

The miners' replies were—

1. in a hurry (22)<sup>a</sup>
2. laziness (15)
3. the area is traveled infrequently (11)
4. too busy doing other work (10)
5. don't want to delay production (10)
6. careless or don't care (8)
7. don't believe it's hazardous (7)
8. it's not their job (7)
9. complacency (6)
10. "I know it's there so I'll just stay away from it" (4)
11. tools or supplies not readily available (4)
12. afraid of getting hurt (4)
13. put off doing it and forget (3)
14. lack of knowledge or experience (2)
15. taking shortcuts (2)
16. not important; it's just "extra work" (2)

Inspectors gave several different types of responses to this question. The most common response was that miners do not think it is worth the time and effort required, i.e., they are insufficiently motivated to correct roof hazards.

Another reason frequently mentioned by mine inspectors was that miners do not realize how dangerous the hazard really is. Several inspectors also said that, because nothing usually happens to miners who occasionally decide to risk working beneath hazardous roof, many tend to become complacent. Apparently, the failure to experience negative consequences for deviating from a safe work practice may promote continued deviation. Other factors believed by mine inspectors to contribute to miners' failure to correct roof hazards were (1) inattentiveness caused by preoccupation with off-the-job problems (e.g., family, medical) and (2) the temptation to let the next shift deal with the hazards when it is close to quitting time.

### Forced-Choice Questions

Participants were asked to indicate the extent to which they agreed or disagreed that various reasons given by the interviewer explain why miners might sometimes decide not to do anything about potentially hazardous roof conditions. A six-point rating scale ranging from "strongly agree"

to "strongly disagree" was used. The rating scale contained the following options:

1. strongly agree
2. agree
3. slightly agree
4. slightly disagree
5. disagree
6. strongly disagree

The number of participants in each subgroup who chose each of these points on the rating scale is presented in tabular form for each question asked. The percentage of participants in each subgroup who chose either "slightly agree," "agree," or "strongly agree" is shown in each table (as "Total 'agree' responses") to allow quick understanding of the general results without additional calculations. (The numbers used in the text of this report to identify the interview questions and statements (reasons) do not correspond to the numbers used in the appendix, but the questions and statements are the same.)

**Reason A.1: One of the main reasons miners sometimes neglect to correct roof hazards is that they don't have the tools or materials with them that are needed to correct the roof problem.**

#### Summary of responses:

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Strongly agree . . . . .	0	6	1	7.1
Agree . . . . .	7	8	1	32.6
Slightly agree . . . . .	0	3	3	11.3
Slightly disagree . . . . .	1	3	2	7.8
Disagree . . . . .	4	14	2	32.6
Strongly disagree . . . . .	2	3	0	8.5
Total "agree" responses . . . . . pct . .	50.0	45.9	55.6	51.0

<sup>1</sup>Does not include MSHA inspectors.

Opinions about this statement were almost evenly split between agreement and disagreement. The data suggest that for many coal miners, an absence of tools and materials needed to fix the roof is a significant barrier to the correction of roof hazards. However, since about half of the people in each work category expressed some level of disagreement, this factor cannot be considered a universal problem. Still, the reasons for the absence of tools and materials for correcting roof hazards should be further explored.

**Reason A.2: One of the main reasons miners sometimes neglect to correct roof hazards is that they think it is someone else's responsibility to take care of roof problems.**

#### Summary of responses:

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Strongly agree . . . . .	3	5	2	9.2
Agree . . . . .	4	11	2	32.4
Slightly agree . . . . .	4	3	1	9.9
Slightly disagree . . . . .	1	2	1	10.6
Disagree . . . . .	2	14	3	31.7
Strongly disagree . . . . .	0	2	0	6.3
Total "agree" responses . . . . . pct . .	78.6	51.4	55.6	51.5

<sup>1</sup>Does not include MSHA inspectors.

<sup>a</sup>Numbers in parentheses indicate the number of persons who replied as indicated.

Opinions about this statement were again almost evenly divided between agreement and disagreement. However, supervisors leaned more heavily toward agreement than disagreement. Only three of 14 supervisors expressed any disagreement, and three said they strongly agreed with this statement. These data suggest that a misperception of freedom from responsibility for taking care of roof problems is a significant deterrent to the correction of roof hazards. This suggests that it is important for supervisors and trainers to strongly emphasize that the identification and correction of hazardous roof conditions is the personal responsibility of *all* people who work in the mine.

**Reason A.3: One of the main reasons miners sometimes neglect to correct roof hazards is because they don't want to risk getting hurt while fixing the roof.**

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Strongly agree . . . . .	0	2	0	5.0
Agree . . . . .	4	5	3	25.0
Slightly agree . . . . .	3	3	0	17.9
Slightly disagree . . . . .	0	6	0	6.4
Disagree . . . . .	7	17	5	40.0
Strongly disagree . . . . .	0	4	0	5.7
Total "agree" responses . . . . . pct . .	50.0	27.0	37.5	47.9

<sup>1</sup>Does not include MSHA inspectors.

Again, responses were about evenly split between agreement and disagreement. However, fewer people agreed with this statement than with the two preceding statements. This was especially true among roof bolters. Because bolters work with the roof every day, they become accustomed to dealing with roof problems, and may be less fearful of being harmed by the roof than persons who do not routinely work with the roof. The data suggest that fear of getting hurt while fixing the roof is sometimes a deterrent to the correction of roof hazards. It may be possible to overcome certain types of fears by improving the miners' ability to cope with potentially dangerous situations and explaining why certain types of fears are not valid. Valid fears should be dealt with by making modifications to the work environment, better training, or withdrawing the person from the dangerous condition.

Data from MSHA's accident records suggest that there are valid reasons why miners might fear they will be hurt while attempting to fix the roof. Scaling loose rock is one of the most common activities associated with rock fall injuries. From 1980-84, 8 pct of all coal miners injured by rock falls were attempting to bar down loose rock from the roof or rib at the time they were hurt. This suggests that improvements such as better training or increased compliance with standard operating procedures are needed, and that fear of harm may be a significant deterrent to the correction of roof hazards.

**Reason A.4: One of the main reasons miners sometimes neglect to correct roof hazards is because they dislike doing the type of work necessary to correct the roof problem.**

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Strongly agree . . . . .	2	5	1	8.1
Agree . . . . .	3	6	4	31.1
Slightly agree . . . . .	4	6	0	18.5
Slightly disagree . . . . .	0	2	1	5.2
Disagree . . . . .	5	14	3	33.3
Strongly disagree . . . . .	0	2	0	3.7
Total "agree" responses . . . . . pct . .	64.3	48.6	55.6	57.7

<sup>1</sup>Does not include MSHA inspectors.

The total sample of miners was split almost evenly between agreement and disagreement. Supervisors leaned more heavily toward agreement than disagreement, while bolters exhibited the opposite tendency. One might expect bolters to be more likely to disagree with this statement, given that the correction of roof problems is a major focus of their job. The responses suggest that a dislike of the work involved in correcting roof problems is sometimes a deterrent to the correction of roof hazards. The sources of dislike for this type of work should be explored further, and if possible, changes should be made that would make the task of correcting roof problems less onerous.

**Reason A.5: One of the main reasons miners sometimes neglect to correct roof hazards is that they believe their supervisor thinks taking care of roof problems is unimportant.**

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Strongly agree . . . . .	0	0	0	0.7
Agree . . . . .	0	2	0	7.8
Slightly agree . . . . .	1	0	1	2.8
Slightly disagree . . . . .	0	0	1	2.8
Disagree . . . . .	8	21	6	56.7
Strongly disagree . . . . .	5	14	1	29.1
Total "agree" responses . . . . . pct . .	7.1	5.4	11.1	11.3

<sup>1</sup>Does not include MSHA inspectors.

There was very little agreement with this statement. Only 11 pct of the total sample of miners expressed agreement with this statement. This data suggests that supervisors' disinterest in correcting roof problems is not a significant barrier to the prevention of groundfall accidents. Given the importance of their role in maintaining the safety of mining crews, any evidence of a supervisor's disinterest in the correction of roof problems should be thoroughly explored.

**Reason A.6: One of the main reasons miners sometimes neglect to correct roof hazards is because they don't know how to correct roof problems.**

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Strongly agree . . . . .	1	1	1	2.9
Agree . . . . .	5	4	1	20.7
Slightly agree . . . . .	3	3	1	12.9
Slightly disagree . . . . .	1	3	1	5.7
Disagree . . . . .	2	22	4	45.7
Strongly disagree . . . . .	2	4	0	12.1
Total "agree" responses . . . . . pct . .	64.3	21.6	37.5	36.5

<sup>1</sup>Does not include MSHA inspectors.

As one might expect, few bolters expressed agreement with this statement. However, about 37 pct of the overall sample expressed agreement with this statement. This suggests that a lack of knowledge about the correction of roof problems is sometimes a deterrent to the correction of roof hazards. Efforts should be made to identify the most effective methods for training miners to correct roof fall problems and to ensure that all persons working underground understand how to correct roof problems.

**Reason A.7: One of the main reasons miners sometimes neglect to correct roof hazards is that they don't realize how dangerous roof problems are.**

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Strongly agree . . . . .	3	8	2	13.7
Agree . . . . .	6	14	5	43.2
Slightly agree . . . . .	0	7	2	11.5
Slightly disagree . . . . .	1	0	0	2.9
Disagree . . . . .	3	6	0	20.9
Strongly disagree . . . . .	1	2	0	7.9
Total "agree" responses . . . . . pct . .	64.3	78.4	100.0	68.4

<sup>1</sup>Does not include MSHA inspectors.

There was a high level of agreement with this statement across all categories of persons who work underground. It appears there may be a tendency for miners to underestimate the level of danger associated with roof problems. Therefore, efforts should be made to impress upon them the magnitude of the damage that uncorrected roof problems can cause to people and equipment.

**Reason A.8: One of the main reasons miners sometimes neglect to correct roof hazards is that they don't take enough time to look for roof problems.**

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Strongly agree . . . . .	3	7	3	11.4
Agree . . . . .	6	14	4	55.0
Slightly agree . . . . .	4	6	1	14.3
Slightly disagree . . . . .	1	2	0	5.0
Disagree . . . . .	0	8	0	14.3
Strongly disagree . . . . .	0	0	0	0.0
Total "agree" responses . . . . . pct . .	93.0	73.0	100.0	80.7

<sup>1</sup>Does not include MSHA inspectors.

There was a high level of agreement with this statement across all categories of persons. Eighty-one percent of the total sample agreed with this statement. The data suggest that a major deterrent to the prevention of groundfall accidents is that miners devote too little time to the visual inspection of the roof and rib. Attention should be given to understanding what could be done to motivate miners to spend more time looking for hazardous roof conditions.

Table 2 rank-orders the above eight reasons in terms of the highest (rank 1) to the lowest (rank 8) percentage of persons who responded that they strongly agreed, agreed, or slightly agreed. With the exception of reason A.5, a significant number of miners agreed that each of the factors listed in this section is an important deterrent to the prevention of groundfall accidents. This suggests that further attention should be given to devising better ways to lessen the influence of these seven barriers.

**Table 2.—Rank ordering of reasons for neglect of roof fall hazards according to percentage of persons expressing agreement<sup>1</sup>**

Reason	All miners <sup>2</sup>	Section supervisors	Roof bolters	MSHA inspectors
A.8. They don't take enough time to look for roof problems . . . . .	1	1	2	1-2
A.7. They don't realize how dangerous roof problems are . . . . .	2	3-5	1	1-2
A.4. They dislike doing the type of work necessary to correct the problem . . . . .	3	3-5	4	4-5
A.2. They think it is someone else's responsibility . . . . .	4	2	3	3
A.1. They don't have the tools or materials to correct the problem . . . . .	5	6-7	5	4-5
A.3. They don't want to risk getting hurt . . . . .	6	6-7	6	6-7
A.6. They don't know how to correct the roof problem . . . . .	7	3-5	7	6-7
A.5. They believe their supervisor thinks that taking care of roof problems is unimportant . . . . .	8	8	8	8

<sup>1</sup>"Agreement" here includes "strongly agree," "agree," and "slightly agree" responses. Ranking of 1 indicates highest percentage of responses in agreement; 8 indicates least agreement.

<sup>2</sup>Does not include MSHA inspectors.

## WHY MINERS SOMETIMES WALK BENEATH UNSUPPORTED ROOF

The victims of roof falls are often found in areas of unsupported roof. MSHA fatality reports indicate that more than half of the 97 deaths due to groundfalls in coal mines during 1979 and 1980 occurred in areas of unsupported roof. The open-ended and forced-choice questions that follow were directed toward better defining the reasons why miners fail to avoid unsupported roof.

### Open-Ended Questions

MSHA roof and rib inspectors were asked what motivates miners to illegally go beneath unsupported roof. (The only legally permissible reason for going beneath unsupported roof is to set temporary supports before installing permanent supports.) The most common reply to this question was that miners do it to save time and/or effort, i.e., they want to take a shortcut.

Inspectors mentioned several factors that sometimes contribute to miners' willingness to risk working beneath unsupported roof. Among them were the following:

1. They are in a hurry to get more coal out, especially if they think they are behind in production.
2. They want to cut down the walking distance to a place they need to go.
3. They think the unsupported roof "looks good" (safe).
4. They do it inadvertently.
5. They have done it before without getting hurt.
6. They are unwilling to set temporary supports.
7. In order to finish loading a shuttle car, continuous miner operators might go a little beyond the edge of properly supported roof.

### Forced-Choice Questions

In this section of the interview, participants were asked forced-choice questions about (1) reasons for walking under unsupported roof, (2) whether miners inspect unsupported roof before walking under it, and (3) the proportion and frequency of miners who walk beneath unsupported roof.

### Reasons for Walking Under Unsupported Roof

Participants were asked to indicate the extent to which they agreed or disagreed that various reasons given by the interviewer explain why miners sometimes walk beneath unsupported roof. Participants again used a six-point rating scale to respond to each statement ("strongly agree," "agree," etc.). Each reason was prefaced by, "One of the main reasons miners sometimes walk beneath unsupported roof is that ..." The participants' responses to these statements are presented in the same manner as those in the preceding section on nonresponse to possible roof hazards.

**Reason B.1: One of the main reasons miners sometimes walk beneath unsupported roof is that they do not realize they have gone beyond the edge of roof that is properly supported and do not intend to do so.**

#### Summary of responses:

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Strongly agree . . . . .	0	3	0	8.5
Agree . . . . .	8	10	2	44.7
Slightly agree . . . . .	1	9	5	12.8
Slightly disagree . . . . .	1	1	0	2.8
Disagree . . . . .	3	10	2	24.8
Strongly disagree . . . . .	1	3	0	6.4
Total "agree" responses . . . . .pct. .	64.3	61.1	77.8	66.0

<sup>1</sup>Does not include MSHA inspectors.

Sixty-six percent of the sample expressed some level of agreement with this statement. Several participants indicated that their answer to this statement would vary depending on the mine's seam height, i.e., it is more difficult to inspect the roof when crawling or stoopwalking than when walking upright.

**Reason B.2: One of the main reasons miners sometimes walk beneath unsupported roof is that they do not believe it is unsafe to do so.**

#### Summary of responses:

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Strongly agree . . . . .	1	1	3	2.9
Agree . . . . .	5	12	5	33.8
Slightly agree . . . . .	3	5	0	12.9
Slightly disagree . . . . .	0	1	0	2.9
Disagree . . . . .	5	14	1	38.1
Strongly disagree . . . . .	0	2	0	9.4
Total "agree" responses . . . . .pct. .	64.3	51.4	88.9	49.6

<sup>1</sup>Does not include MSHA inspectors.

Miners' opinions about this statement were about evenly split between agreement and disagreement. However, supervisors and mine inspectors leaned more heavily toward agreement. All but one of nine inspectors agreed or strongly agreed with this statement.

It is not hard to understand why some miners might become convinced that unsupported roof is safe. First, there is often no way miners can anticipate when unsupported roof is going to collapse. Except for the absence of supports, unsupported roof may look entirely safe. In most mines, roof falls leading to serious injury are not a common occurrence, and miners can often go beneath unsupported roof without being injured. The more times a miner goes beneath unsupported roof without being injured, the more convinced he or she will be that unsupported roof is not dangerous. Although roof falls are not an everyday event, they all too often produce disastrous consequences when they occur. It is particularly important to keep new miners from forming the habit of going beneath unsupported roof, because habits are difficult to break.

**Reason B.3: One of the main reasons miners sometimes walk beneath unsupported roof is that they are trying to save time.**

#### Summary of responses:

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Strongly agree . . . . .	0	5	0	8.6
Agree . . . . .	8	20	7	58.6
Slightly agree . . . . .	3	6	1	11.4
Slightly disagree . . . . .	1	2	0	5.0
Disagree . . . . .	2	3	1	15.0
Strongly disagree . . . . .	0	0	0	2.0
Total "agree" responses . . . . .pct. .	78.6	86.1	88.9	78.6

<sup>1</sup>Does not include MSHA inspectors.

There was a high level of agreement with this statement across all categories of participants. It would be useful to understand the types of circumstances most likely to cause miners to take dangerous shortcuts in order to save time. Because the activities of mining coal and roof bolting are somewhat interdependent, significant delays in roof bolting might motivate bolters to take dangerous shortcuts in order to catch up with the rest of the cycle of mining activities in their section.

Therefore, mine operators should be especially concerned with planning for and dealing with unplanned events that could delay roof bolting activities. It might be possible to prevent such delays through modification of work procedures or equipment.

**Reason B.4: One of the main reasons miners sometimes walk beneath unsupported roof is that it takes too much effort to set temporary supports.**

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Strongly agree . . . . .	1	2	2	8.8
Agree . . . . .	7	11	2	37.5
Slightly agree . . . . .	2	5	2	13.2
Slightly disagree . . . . .	0	1	1	1.5
Disagree . . . . .	4	9	2	30.9
Strongly disagree . . . . .	0	7	0	8.1
Total "agree" responses . . . . .pct. .	71.4	51.4	66.7	59.5

<sup>1</sup>Does not include MSHA inspectors.

The majority of each category of participant expressed agreement with this statement. This suggests that consideration should be given to redesigning the equipment and procedures associated with setting temporary roof supports. The Bureau of Mines recently developed a new roof jack that is lighter in weight and easier to carry than previous roof jacks. Any improvements that would make the task of temporary roof support easier would help miners to overcome this barrier to the prevention of groundfall accidents.

**Reason B.5: One of the main reasons miners sometimes walk beneath unsupported roof is that they have often seen other people do it.**

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Strongly agree . . . . .	1	8	0	10.9
Agree . . . . .	8	14	5	51.4
Slightly agree . . . . .	2	2	1	9.4
Slightly disagree . . . . .	0	2	2	2.2
Disagree . . . . .	2	8	1	22.5
Strongly disagree . . . . .	0	2	0	3.6
Total "agree" responses . . . . .pct. .	84.6	66.7	66.7	71.7

<sup>1</sup>Does not include MSHA inspectors.

There was a high level of agreement with this statement across all categories of participants. This suggests that walking beneath unsupported roof may be analogous to a contagious disease. It not only poses a threat to the well-being of the individual who is beneath the unsupported roof, it is also likely to spread to others in the vicinity. Observing that no harm comes to coworkers who walk beneath unsupported roof causes others to be less cautious. Walking beneath unsupported roof could become commonplace among members of a mining crew. In such crews, the peer group pressure to engage in this dangerous practice might be very difficult to overcome.

Miners' responses to this question suggest that walking beneath unsupported roof is a potentially contagious behavior. Therefore, it is important that such behavior be quickly eliminated, because if it is tolerated, it is likely to spread among the work force.

Table 3 rank-orders the first five statements in terms of the highest (rank 1) to the lowest (rank 5) percentage of persons who responded that they strongly agreed, agreed, or slightly agreed. At least half of the total miners group

**Table 3.—Rank ordering of reasons why miners go beneath unsupported roof according to percentage of persons expressing agreement<sup>1</sup>**

Reason	All miners <sup>2</sup>	Section supervisors	Roof bolters	MSHA inspectors
B.3. They are trying to save some time . . . . .	1	2	1	1-2
B.5. They have often seen other people do it . . . . .	2	1	2	4-5
B.1. They do not realize they have gone beyond the edge of roof that is properly supported, and did not intend to do so . . . . .	3	4-5	3	3
B.4. It takes too much time to set temporary supports . . . . .	4	3	4-5	4-5
B.2. They do not believe it is unsafe to do so . . . . .	5	4-5	4-5	1-2

<sup>1</sup>"Agreement" here includes "strongly agree," "agree," and "slightly agree" responses. Ranking of 1 indicates highest percentage of responses in agreement; 5 indicates least agreement.

<sup>2</sup>Does not include MSHA inspectors.

expressed agreement with all five statements. This suggests that (1) all of the reasons listed in this section were considered to be important reasons why miners sometimes go beneath unsupported roof by a substantial number of participants and (2) that attention should be given to devising effective methods for counteracting these reasons.

## Precautionary Behavior

In order to roughly estimate whether most miners stop to visually inspect unsupported roof before walking beneath it, miners were asked if they agreed or disagreed with the following statement:

**Statement B.6: Most miners do not walk beneath unsupported roof before looking at it carefully.**

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Strongly agree . . . . .	0	5	0	6.6
Agree . . . . .	8	22	3	68.4
Slightly agree . . . . .	3	3	2	12.5
Slightly disagree . . . . .	2	2	3	3.7
Disagree . . . . .	1	3	1	7.4
Strongly disagree . . . . .	0	1	0	1.5
Total "agree" responses . . . . .pct. .	78.6	83.3	55.6	87.5

<sup>1</sup>Does not include MSHA inspectors.

A substantial majority of all three categories of mine employees expressed agreement with this statement. This suggests that miners who walk beneath unsupported roof are somewhat fearful of being struck by a roof fall, and at least stop to visually inspect the roof before proceeding out beyond the edge of supported roof.

## Proportion and Frequency of Miners Walking Beneath Unsupported Roof

In order to roughly estimate the proportion of miners who go beneath unsupported roof, miners were asked, "During a typical month, what percentage of miners who work at the face go beneath unsupported roof for reasons other than to set temporary supports?" Miners' responses to this question are given in table 4. The median of the estimates for the percentage of miners who go beneath unsupported

roof during a typical month was 10 pct. (Half of the estimates were greater than 10 pct and half the estimates were less than 10 pct.) This suggests that the percentage of miners who go beneath unsupported roof is relatively low.

In order to estimate the frequency with which miners go beneath unsupported roof, miners were asked, "Considering a typical crew of miners who work at the face, how often does someone go beneath unsupported roof for reasons other than to set temporary supports?" Miners' responses to this question are listed in table 5. Approximately 44 pct of the miners indicated that they believe someone goes beneath unsupported roof at least once per shift.

**Table 4.—Estimates of percentage of miners who go beneath unsupported roof during a typical month**

Estimate, pct	Miners in agreement with estimate	Miners in agreement with estimate, pct
0 .....	34	27.2
1 .....	9	7.2
2 .....	8	6.4
5 .....	9	7.2
9 .....	1	.8
10 .....	21	16.8
15 .....	2	1.6
20 .....	7	5.6
25 .....	7	5.6
30 .....	4	3.2
35 .....	2	1.6
50 .....	13	10.4
60 .....	1	.8
75 .....	2	1.6
80 .....	2	1.6
90 .....	2	1.6
100 .....	1	.8
Total .....	125	100.0

**Table 5.—Estimates of frequency with which someone in a typical crew of miners goes beneath unsupported roof**

Estimate, pct	Miners in agreement with estimate	Miners in agreement with estimate, pct
At least once per shift ..	48	43.6
At least once per week, but less often than once every shift .....	28	25.4
At least once per month, but less often than once every week .....	16	14.6
Less than once per month .....	18	16.4
Total .....	110	100.0

Over 25 pct indicated that they believed someone goes beneath unsupported roof at least once per week but not as often as once per shift. These estimates suggest that going beneath unsupported roof is not an uncommon event in a typical mining crew, and, that more attention should be given to preventing miners from engaging in this practice. In conjunction with the data from table 4, these estimates suggest that few miners go beneath unsupported roof, but that those who do, do it rather often.

## OPINIONS ON VARIOUS MEASURES FOR PREVENTING GROUNDFA LL ACCIDENTS

Each participant was initially asked to respond to an open-ended question concerning measures that could be

taken to prevent groundfall accidents. This question was followed by nine forced-choice questions.

## Open-Ended Questions

Miners were asked for their opinions about what should be done to reduce the number of rock fall accidents in the coal industry. Their replies were—

1. better training (19)<sup>5</sup>
2. inspect the roof more often (14)
3. don't make entries too wide (7)
4. drill test holes more frequently and/or deeper (7)
5. always set temporary supports before walking beyond bolts (7)
6. put more emphasis on the dangerousness of ground-fall accidents (7)
7. follow the roof control plan and/or bolting pattern more closely (6)
8. use more automated temporary roof support (ATRS) type bolters (5)<sup>6</sup>
9. recheck existing supports more often (5)
10. add more supports to bad areas (5)
11. stricter supervision (4)
12. use more bolts (4)
13. use longer bolts (4)
14. don't rush (4)
15. put less emphasis on production (3)
16. scale the roof better (2)
17. check the torque on roof bolts more often (2)
18. sound the roof more often (2)
19. more safety talks (2)

Other responses included the following: put canopies on roof bolters, operate equipment by remote control, offer bonuses for good roof support, install roof supports more quickly after the area is mined, install bolts closer to the rib, encourage communication between miners about the existence of new roof problems, and explain some of the theoretical principles behind roof support.

MSHA inspectors were also asked what they thought needs to be done to prevent more roof fall accidents in the coal industry. The most common response was that the use of ATRS systems on bolters should be mandatory. Such systems are expected to significantly reduce the amount of time miners spend beneath unsupported roof. Other responses included:

1. Use remote sensing devices to check for gas at the face.
2. Do not assign inexperienced crews to perform retreat mining.
3. Encourage continuous miner operators to report roof problems to bolters.
4. Avoid letting sections stand idle during pillar recovery.

<sup>5</sup>Numbers in parentheses indicate the number of persons who replied as indicated.

<sup>6</sup>Unsupported coal mine roof must be temporarily supported (usually with jacks) before permanent supports (usually bolts) are installed. Without the ATRS system, bolters must expose themselves to unsupported roof in order to set the temporary supports. Bolting machines equipped with ATRS support the roof with hydraulic jacks mounted at the front of the machine while roof bolts are being installed. This eliminates the need for miners to expose themselves to unsupported roof while temporary supports are set.

5. Ensure closer compliance with the roof control plan and safety rules.
6. Improve training.

With regard to the improvement of training, inspectors recommended the following:

1. Supplement classroom training with structured on-the-job training in roof control and identification of ground-fall hazards.
2. Explain the theory behind current methods of roof support to bolters in lay terms.
3. Limit the size of training classes to encourage more discussion.
4. Increase miners' awareness of the consequences of roof falls by showing slides of roof fall accidents and relating the details of how people have been injured by them.

### Forced-Choice Questions

Participants were asked to indicate the degree to which various changes would help miners avoid rock fall injuries. A six-point rating scale ranging from "a very small degree" to "a very large degree" was used to respond to each statement. The rating scale contained the following options:

1. a very small degree
2. a small degree
3. a somewhat small degree
4. a somewhat large degree
5. a large degree
6. a very large degree

Nine different changes (environmental, procedural, etc.) were inserted into the blank in the following question: To what degree would \_\_\_\_\_ help miners avoid rock fall injuries? The number of participants in each subgroup who chose each point on the rating scale is presented below. The last row of numbers indicates the percentage of participants in each subgroup who either chose "a large degree" or "a very large degree" to answer the question. These percentages allow quick understanding of the general results without any additional calculations.

#### Question C.1: To what degree would better lighting help miners avoid rock fall injuries?

##### Summary of responses:

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Very small . . . . .	3	3	1	14.2
Small . . . . .	3	11	2	26.9
Somewhat small . . . . .	1	3	2	9.7
Somewhat large . . . . .	2	2	2	5.2
Large . . . . .	3	8	2	30.6
Very large . . . . .	1	5	0	13.4
Large or very large . . . . . pct . . . . .	30.8	40.6	22.2	44.0

<sup>1</sup>Does not include MSHA inspectors.

Forty-four percent of the mine employees said better lighting would help miners avoid rock fall injuries to a large or very large degree. Indexes of dangerous roof conditions such as cracks and gaps in the rock would probably be noticed more readily if mine roofs were better illuminated.

(However, this may not always be feasible.) Another barrier to the recognition of such indexes of dangerous roof and rib rock is poor eyesight. Periodic vision tests would help to ensure that miners can see well. Good vision is especially important for those who work in areas where hazardous roof conditions are likely to exist.

#### Question C.2: To what degree would less noise help miners avoid rock fall injuries?

##### Summary of responses:

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Very small . . . . .	2	4	0	7.5
Small . . . . .	1	9	2	19.4
Somewhat small . . . . .	2	0	2	6.0
Somewhat large . . . . .	1	2	1	11.2
Large . . . . .	6	12	3	38.1
Very large . . . . .	2	5	1	17.9
Large or very large . . . . . pct . . . . .	57.2	53.1	44.4	56.0

<sup>1</sup>Does not include MSHA inspectors.

Fifty-six percent of the mine employees said less noise would be a large or very large help. Indexes of dangerous roof conditions such as cracking and pinging sounds and small pieces of rock falling to the floor sometimes warn miners that a roof fall is imminent. However, such sounds are likely to go unnoticed if noisy equipment is operating in the vicinity. Therefore, efforts should be made to keep face areas as free from noise as possible.

#### Question C.3: To what degree would supervisors putting greater emphasis on correcting roof hazards help miners avoid rock fall injuries?

##### Summary of responses:

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Very small . . . . .	1	4	0	6.7
Small . . . . .	1	6	0	15.6
Somewhat small . . . . .	0	3	0	4.4
Somewhat large . . . . .	2	4	2	17.0
Large . . . . .	7	10	4	37.8
Very large . . . . .	3	5	3	18.5
Large or very large . . . . . pct . . . . .	71.4	46.9	77.8	56.3

<sup>1</sup>Does not include MSHA inspectors.

Fifty-six percent of the mine employees said that supervisors putting greater emphasis on correcting roof hazards would be a large or very large help. The percentage of supervisors who chose these two response categories (71.4 pct) was higher than the corresponding percentage for all miners (56.3 pct), and the corresponding percentage for inspectors was even higher (77.8 pct). Section supervisors play a critical role in maintaining their crews' safety. It is essential that supervisors do a good job of emphasizing the maintenance of safe roof conditions. It may be necessary to help supervisors who are not effective at this aspect of their job by providing them with additional training on supervisory skills and/or ground control.

#### Question C.4: To what degree would better training in the identification of roof hazards help miners avoid rock fall injuries?

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Very small . . . . .	1	1	0	3.0
Small . . . . .	2	2	1	6.0
Somewhat small . . . . .	1	3	0	6.8
Somewhat large . . . . .	2	3	4	15.8
Large . . . . .	3	15	2	45.1
Very large . . . . .	5	6	2	23.3
Large or very large . . . . .pct . . . . .	57.1	70.0	44.4	68.4

<sup>1</sup>Does not include MSHA inspectors.

Sixty-eight percent of the mine employees said better training in the identification of roof hazards would help miners avoid rock fall injuries to a large or very large degree. This suggests that an important barrier to miners' prevention of groundfall accidents is that miners are unable to recognize certain types of roof conditions as hazardous. (The Bureau is helping to alleviate this problem by developing a comprehensive set of stereoscopic slides of groundfall hazards than can be used to illustrate these hazards and show miners how to correct them. Stereoscopic slides provide a much more realistic representation of groundfall hazards than can be achieved through conventional slides.)

MSHA inspectors were asked to list the types of cues that can warn miners that a piece or an area of the roof is about to fall. They were then asked to choose which of these warning signals would be most difficult for inexperienced miners to recognize as indicators of danger. The following visual cues were mentioned:

1. cracked, bent, or broken support posts
2. cracks, gaps, slips, cutters, and clay veins in the roof and rib
3. heaving of the floor
4. loose rock lying on the floor
5. the absence of rock dust on previously dusted surfaces
6. bent plates around bolts
7. cracked, bent, broken, or squeezed cap blocks, cross-bars, or cribs
8. sags in the middle of the roof or crossbars
9. reduction in clearance between tops of equipment and the roof over time
10. dust trickling down from the roof
11. water seeping out of roof bolt holes
12. kettlebottoms and other fossils

The following auditory cues were mentioned:

1. sounds associated with "sounding the roof"
2. noise caused by shifts in the stress distribution on various layers of rock, i.e., when the roof is "working"
3. cracking of wooden supports due to stress concentrations
4. pinging noises from roof bolts caused by increased roof loading

It was noted that roof bolters receive several types of cues about the stability of the roof when drilling bolt holes. It was also noted that these warning signals are not universal; they may vary with the type of coal seam and geological conditions.

Responses to the question, "Which types of warning signals are more difficult for inexperienced miners to recognize (as opposed to miners with several years of experience)?" included clay veins, cutters, sloughing of the

ribs, cracking or heaving of the floor, the presence of sand-stone channels, and pinging noises produced by bolts.

**Question C.5: To what degree would better training in proper methods of supporting the roof help miners avoid rock fall injuries?**

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Very small . . . . .	1	0	0	2.3
Small . . . . .	3	5	1	11.3
Somewhat small . . . . .	0	1	1	3.0
Somewhat large . . . . .	2	4	2	14.3
Large . . . . .	5	14	3	43.6
Very large . . . . .	3	7	2	25.6
Large or very large . . . . .pct . . . . .	57.1	67.8	55.6	69.2

<sup>1</sup>Does not include MSHA inspectors.

Sixty-nine percent of the mine employees said better training in proper methods of supporting the roof would be a large or very large help. This suggests that miners' lack of knowledge concerning proper methods of roof support is an important barrier to the prevention of groundfall accidents. This type of training should be conducted both in the classroom and underground. It is important that miners get hands-on experience under the close supervision of someone knowledgeable in the proper methods of roof support.

**Question C.6: To what degree would reprimanding or penalizing those who repeatedly go beneath unsupported roof help miners avoid rock fall injuries?**

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Very small . . . . .	1	4	0	10.4
Small . . . . .	2	8	1	14.8
Somewhat small . . . . .	2	2	1	5.2
Somewhat large . . . . .	1	0	1	9.6
Large . . . . .	5	8	4	28.9
Very large . . . . .	3	10	2	31.1
Large or very large . . . . .pct . . . . .	57.1	56.3	66.7	60.0

<sup>1</sup>Does not include MSHA inspectors.

The majority of participants in each category said that reprimands or penalties would be a large or very large help. This suggests that section supervisors should not hesitate to reprimand and penalize individuals who repeatedly go beneath unsupported roof if other methods of convincing them not to do this prove ineffectual. These data suggest that most miners believe such actions are likely to be effective. Again, it is important that supervisors take whatever actions are necessary to stop miners from going under unsupported roof as soon as possible—before it becomes habitual and commonplace.

**Question C.7: To what degree would better scaling of the roof help miners avoid rock fall injuries?**

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Very small . . . . .	0	1	0	2.2
Small . . . . .	4	7	1	17.2
Somewhat small . . . .	2	3	1	8.2
Somewhat large . . . .	2	5	2	15.7
Large . . . . .	4	11	3	37.3
Very large . . . . .	2	5	0	19.4
Large or very large . . . . . pct . . . . .	42.9	50.0	42.9	56.7

<sup>1</sup>Does not include MSHA inspectors.

Fifty-seven percent of the mine employees said better scaling of the roof would help miners avoid rock falls to a large or very large degree. This suggests that there is often a need for more emphasis on keeping the roof properly scaled. It is important that miners realize and be reminded that it is necessary to take down even relatively small pieces of loose rock, because it does not take much rock to cause a serious injury or fatality.

**Question C.8: To what degree would adding more support to bad areas of the roof help miners avoid rock fall injuries?**

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Very small . . . . .	1	0	0	3.0
Small . . . . .	2	2	1	5.3
Somewhat small . . . .	1	1	1	3.8
Somewhat large . . . .	1	4	2	9.0
Large . . . . .	5	16	4	39.8
Very large . . . . .	4	9	0	39.1
Large or very large . . . . . pct . . . . .	64.3	78.1	50.0	78.9

<sup>1</sup>Does not include MSHA inspectors.

Seventy-nine percent of the mine employees said that adding more support to bad areas of the roof would be a large or very large help. This suggests that it is important to make sure the roof has not deteriorated to the point of being dangerous.

**Question C.9: To what degree would better installation of roof bolts help miners avoid rock fall injuries?**

**Summary of responses:**

Rating	Section supervisors	Roof bolters	MSHA inspectors	All miners, <sup>1</sup> pct of total
Very small . . . . .	1	2	0	6.1
Small . . . . .	3	10	3	25.8
Somewhat small . . . .	2	1	4	5.3
Somewhat large . . . .	3	1	0	9.8
Large . . . . .	3	9	2	25.8
Very large . . . . .	2	8	0	27.3
Large or very large . . . . . pct . . . . .	35.7	54.8	22.2	53.1

<sup>1</sup>Does not include MSHA inspectors.

It is interesting that the percentage of roof bolters who chose either the "large" or "very large" response (54.8 pct) was substantially higher than the corresponding percentage for supervisors (35.7 pct) and for MSHA inspectors (22.2 pct). Because bolting is the central focus of their work, bolters may tend to exaggerate the importance of inadequate bolting as a contributor to groundfall accidents. These

data suggest that better bolting could help reduce the occurrence of groundfall accidents. Research should be conducted to discover the types of errors commonly made by bolters, why these errors occur, and how they can be prevented.

Table 6 rank-orders the nine questions in this section in terms of the highest (rank 1) to the lowest (rank 9) percentage of persons who chose either the "large" or "very large" responses. Better lighting received the lowest ranking from all four subgroups. The ranking for less noise was relatively low for all of the subgroups except supervisors. "Supervisors putting greater emphasis on correcting roof hazards" was ranked highest by supervisors and MSHA inspectors, but was ranked relatively low by all miners and roof bolters. Rankings for better training in the identification of roof hazards, better training in proper methods of supporting the roof, and reprimanding or penalizing those who repeatedly go beneath unsupported roof were in the middle range (between 2 and 6). Adding more support to bad areas of the roof was ranked number 1 by the total miners group and by roof bolters, and was ranked number 2 by supervisors. Better installation of roof bolts ranked nearly last. Items C.1, C.2, C.7, C.8, and C.9 all refer to changing the physical work environment, whereas items C.3 through C.6 all refer to changes in miners' training and supervision. Except for item C.8, there was a consistent tendency across all subgroups for the percentages of participants in the "large" or "very large" response categories (with the responses referring to degree of help) to be higher for the proposed changes in training and supervision than for the proposed changes in the physical work environment.

Except for better lighting, the majority of the total miners group indicated that all of the proposed changes would help miners avoid rock fall injuries to a large or very large degree. (The corresponding percentage for better lighting was 44 pct.) The perceived importance of the nine changes proposed in this section for reducing rock fall injuries suggests that consideration should be given to the possibility of implementing all nine of them. Obviously, some of these changes are not as feasible as others. Their feasibility could be determined by several factors, including the cost of research and implementation and the probability of success.

**Table 6.—Rank ordering of responses about degree to which various changes would help miners avoid rock fall injuries, according to percentage of persons who chose "large" or "very large" degree response<sup>1</sup>**

Reason	All miners <sup>2</sup>	Section supervisors	Roof bolters	MSHA inspectors
C.8. Adding more support to bad areas of the roof . .	1	2	1	4
C.5. Better training in proper methods of supporting the roof . . . . .	2	4-6	3	2
C.4. Better training in the identification of roof hazards . . . . .	3	4-6	2	5-6
C.6. Reprimanding or penalizing those who repeatedly go beneath unsupported roof . . . .	4	4-6	4	2
C.7. Better scaling of the roof .	5	7	7	7
C.3. Supervisors putting greater emphasis on correcting roof hazards	6	1	8	1
C.2. Less noise . . . . .	7	3	6	5-6
C.9. Better installation of roof bolts . . . . .	8	8	5	8-9
C.1. Better lighting	9	9	9	8-9

<sup>1</sup>Ranking of 1 indicates highest percentage of responses in "large" or "very large" categories; 9 indicates lowest percentage in these categories.

<sup>2</sup>Does not include MSHA inspectors.

## MINERS' EXPERIENCES WITH ROCK FALLS

The most comprehensive source of data about groundfalls is maintained by MSHA's Health and Safety Analysis Center in Denver, CO. Several breakdowns and statistics were generated from MSHA's records on groundfall accidents. These data are quite informative and useful and are presented later in this section. However, several other types of potentially useful information about groundfalls are not available from MSHA. Therefore, the miners interviewed for this study were asked to provide information about their recent experiences with rock falls that is not typically collected by MSHA. Miners were asked for detailed information about either (1) recent injuries they had suffered as a result of a rock fall or (2) incidents in which they were startled due to their proximity to large pieces of falling rock.

### EXPERIENCES REPORTED BY THE MINERS IN THIS STUDY

Miners were asked several questions about their experiences with rock fall accidents. (These questions are listed in the appendix.) The responses to these questions are summarized in two sections. The first section ("Injured") summarizes data from 31 miners who had suffered some type of injury caused by a rock fall during the preceding 2 yr. The second section ("Not Injured") summarizes data from 57 other miners who had not been recently injured, but had been startled by large pieces of falling rock sometime during the past year.

#### Injured

Ten miners reported that they had suffered a lost-time injury due to a rock fall sometime during the past 2 yr. Twenty-one others said they had suffered an injury due to a rock fall without lost time sometime during the past year. When asked where they were when the injury occurred, 25 of these 31 miners said they were within approximately 25 ft of the face. When asked how long they had been near the location of the rock fall before the fall actually occurred, 20 of these 31 miners reported that they had been there for only a few minutes prior to the accident. The activities being performed at the time of the accident were—

1. roof bolting (15)<sup>7</sup>
2. setting temporary supports (4)
3. standing or walking (3)
4. operating a continuous miner (3)
5. operating a shuttle car (2)
6. shoveling (1)
7. putting up a brattice (1)
8. eating dinner (1)
9. sawing a timber (1)

#### Not Injured

Of the 119 persons who had not recently been injured by a rock fall, 57 said they had been startled by large pieces of falling rock sometime during the past year. Of these 57 individuals, 46 reported that such an incident had happened more than once within the past year. The median number

<sup>7</sup>Numbers in parentheses indicate the number of persons who replied as indicated.

of such incidents reported by these 46 persons was 3. Thirty-two of the 57 miners reported that they had been near the location of the rock fall only a few minutes prior to the time that the rock fell.

These data suggest that unplanned rock falls in underground coal mines are a somewhat common event. Of the 143 miners interviewed for this study, 88 reported having had some type of recent experience with a rock fall. (This includes rock falls that produced injuries and those which were close enough to startle nearby miners.) Of these 88 incidents, 66 occurred within approximately 25 ft of the face.

It is surprising that 52 of these incidents occurred within only a few minutes after the miner had arrived at the area where the fall occurred. This suggests that it is very important for miners to take the time to check the roof whenever they go to a new part of the mine. It suggests that many rock fall accidents could be avoided if miners would always check the roof before beginning to work in a new area.

### NATIONAL STATISTICS

The injuries indicated in the statistics presented below are those in which a coal miner suffered an injury due to falling rock while working at an underground location. The data are derived from reports operators of U.S. coal mines submitted to MSHA concerning injuries their employees suffered while at work during 1980-84. Employers are required by 30 CFR 50.2 to report to MSHA all injuries that cause an employee to miss one or more days of work. Employers are also required to report groundfalls and certain other types of dangerous accidents to MSHA regardless of whether or not anyone was injured. During 1980-84, 16,352 groundfall accidents were reported to MSHA by the operators of underground coal mines. These accidents resulted in 181 fatalities, 4,571 lost-time injuries, and 752 injuries without lost time.

The following list shows the percentage breakdown, by the nature of the injury, for the 4,571 lost-time accidents caused by groundfalls:

Bruises and contusions . .	32.9
Fractures and chips . . . .	21.1
Multiple injuries . . . . .	17.2
Cuts and lacerations . . . .	9.2
Sprains and strains . . . . .	8.2
Other . . . . .	11.5

These data suggest that groundfalls often produce relatively severe types of injuries, including broken bones and serious cuts. The average number of workdays lost following these injuries was 35.3 days.

Frequency breakdowns of the injury data are presented below for the following variables: the location of the rock fall, the type of task being performed, the victim's job classification, the victim's length of experience as a coal miner, length of experience in the current job classification, and the amount of time that had elapsed since the shift began.

Table 7 breaks down groundfall accidents by the location of the accident. These data suggest that intersections are the most common site of groundfall occurrences. About

**Table 7.—Breakdown of groundfall accidents (1980-84), by location, percent**

Location	Accidents without injury	Injuries	Fatalities
Face .....	11.2	52.2	60.8
Intersections.....	52.5	10.1	19.3
Other .....	36.3	37.7	19.9
Total number ....	10,848	5,323	181

half of the groundfalls occurred in intersections, as well as roughly 1 in 5 groundfall fatalities. However, the most common location for miners to be injured or killed by a groundfall is the face area. Two of the main reasons that most injuries and fatalities occur in face areas are that (1) the face often contains unsupported roof, and (2) more worker-hours are worked in face areas than in other areas of the mine.

Table 8 breaks down injuries and fatalities caused by rock falls by the type of activity being performed. The data indicate that the types of activities most commonly being performed at the time of an injury-producing rock fall were handling supplies; roof bolting; barring down rock; idle or observing operations; setting, removing, or relocating props; and operating a continuous miner. Activities accounting for at least 5 pct of the fatalities were roof bolting; setting, removing, or relocating props; operating a continuous miner; idle or observing operations; handling supplies; timbering or cribbing; barring down rock; and walking. The 14 activities listed in table 8 accounted for about three-fourths of all injury-producing rock falls and about four-fifths of all groundfall fatalities. As one might expect, most fatalities occurred during the installation or removal of devices to support the roof or rib. Activities associated with groundfall fatalities are discussed further in a later section.

**Table 8.—Breakdown of injuries and fatalities caused by rock falls (1980-84), by activity, percent**

Activity	Injuries	Fatalities
Handling supplies .....	10.8	7.8
Roof bolting .....	10.2	13.2
Barring down rock .....	8.0	5.0
Idle or observing operations .....	7.6	8.3
Setting, removing, or relocating props .....	6.0	9.4
Operating continuous miner .....	5.8	8.8
Walking .....	4.8	5.0
Machine repair and maintenance .....	4.3	3.3
Timbering or cribbing ..	4.2	7.2
Moving power cable ...	3.3	2.8
Shoveling or hand loading rock or coal ..	3.1	3.9
Operating shuttle car ...	2.3	0.6
Operating scoop .....	2.2	3.9
Setting brattice .....	2.2	1.1
Other .....	25.2	19.7
Total number .....	5,504	181

The data in table 9 show that roof bolters accounted for a far greater percentage of fatalities than any other job. The most frequent victims of groundfall fatalities were bolters, laborers, helpers, and miner operators. Together, they accounted for 55.7 pct of the fatalities. An unusual finding was that although supervisors accounted for only 7.6 pct of all groundfall injuries during 1980-84, they accounted for 13.4 pct of all fatalities caused by groundfalls. Because supervisors may feel that it is their responsibility to ensure

that their crews do not get hurt, they may tend to perform unusually hazardous tasks themselves rather than expose one of their crew to the danger.

**Table 9.—Breakdown of injuries and fatalities caused by rock falls (1980-84), by job title, percent**

Job title	Injuries	Fatalities
Roof bolter .....	17.6	23.8
Roof bolter helper .....	4.5	5.5
Continuous miner operator .....	8.4	5.5
Continuous miner helper .....	6.6	9.9
Laborer, face advance worker .....	14.2	11.0
Section supervisor .....	2.8	5.0
Laborers' supervisor ...	2.7	5.0
Mine supervisor or superintendent .....	2.1	3.4
Shuttlecar operator .....	6.4	2.8
Timber worker, jack-setter .....	5.5	5.6
Mechanic, repair worker .....	4.4	1.1
Scoop operator .....	3.8	5.5
Other .....	21.2	15.9
Total number .....	5,504	181

Table 10 breaks down injuries due to rock falls by the years of experience the victim had in his or her current job classification and his or her total years of experience as a coal miner. There appeared to be a steady increase in the number of injuries per year of mining experience for each of the first 6 yr. After these first 6 yr, there was a trend toward declining numbers of injuries. One reason for the initial low numbers of injuries was that the number of new miners entering the work force during 1980-84 was lower than in most other time periods. Another reason may have been that miners are not usually assigned to work in face areas when they are first hired and therefore are not as likely to be exposed to areas of unsupported roof.

**Table 10.—Breakdown of injuries caused by rock falls (1980-84), by experience as a miner and experience in current job classification, percent**

Experience, yr	Injuries broken down by experience—	
	As a coal miner	At current type of job
0-1 .....	5.9	33.0
1-2 .....	7.5	18.8
2-3 .....	8.4	11.7
3-4 .....	8.5	7.9
4-5 .....	8.9	7.2
5-6 .....	9.4	5.4
6-7 .....	7.8	2.5
7-8 .....	7.0	2.9
8-9 .....	5.3	1.6
9-10 .....	6.6	2.5
10+ .....	24.7	5.5
Total number ...	5,033	4,400

The breakdown of injuries by number of years of experience performing the current job shows a pattern of continual decline. Almost one-third of all groundfall injuries were suffered by miners who were in their first year on a new job. One reason why those with so little job experience accounted for most of the accidents may be that learning a new job requires that the miner devote less attention to avoiding hazards. This is because, during the learning stage, effective job performance requires a relatively greater amount of attention to new tasks than later, when task performance becomes more habitual. The decrease in injuries with greater job experience may also reflect the fact that

it takes time for miners to learn to recognize rock hazards in new areas of the mine in which their new job requires them to work. However, it would be necessary to collect additional data to determine the validity of these two possible explanations for the trend observed. It could also be that the decline in injuries with increased job experience merely reflected the fact that there were fewer mines who had higher amounts of job experience.

Table 11 breaks down the injuries caused by rock falls by the time elapsed since the shift began. This data shows that most rock fall injuries occurred during the third and fourth hours after the shift began. Injuries during the fifth hour were 4.5 pct lower than those for the preceding hour. This relatively large drop in injuries may be largely due to a tendency for miners to be absent from the face area for at least a part of this hour while they take a mid-shift break from work.

**Table 11.—Breakdown of injuries caused by rock falls (1980-84), by time elapsed since the shift began, percent**

Time, h	Injuries
0-1	3.7
1-2	12.2
2-3	16.3
3-4	16.7
4-5	12.2
5-6	12.9
6-7	13.8
7-8	8.7
Over 8	12.1
Total number	5,419

## ANALYSIS OF DATA FROM MSHA FATALITY REPORTS

MSHA's reports on 97 deaths caused by groundfalls in coal mines during 1979 and 1980 were reviewed in order to better understand the conditions or events which may have contributed to these accidents. Nearly all of the victims were found at or near the face area, and most of them were beneath unsupported roof. Table 12 summarizes what rock fall victims were probably doing at the time the rock fell. As might be expected, most fatalities occurred during the installation or removal of devices to support the roof. A somewhat unexpected finding was that many victims (13 pct) were reported to have been passively watching someone else work at the time of the accident.

**Table 12.—Breakdown of fatalities caused by rock falls (1979-80), by activity**

	Number
Installing posts, jacks, cross bars, rib boards	17
Observing someone else work	13
Operating equipment	8
Removing jacks and posts	7
Installing roof bolts	6
Hand loading or shoveling ore	4
Attending to trailing cable from continuous miner	4
Waiting to bolt	3
Marking roof for bolts	3
Scaling roof	3
Drilling holes for roof bolts	2
Walking	2
Examining broken jack	1
Spraying continuous miner while operating	1
Carrying supplies	1
Repairing cable to continuous miner	1
Examining area recently mined out	1
Testing roof with pick	1
Talking	1
Inserting a bolt	1
Unknown	16
Total	97

Given the high degree of interdependency among many mining tasks, it is not uncommon for miners to have to wait for short periods of time for their coworkers to finish a task before they can resume working. One might speculate that the reason individuals are so often hurt by roof falls while watching someone else is that, because they are absorbed in what someone else is doing, they stop attending to cues concerning hazards in their immediate environment. Also, there may be a tendency for individuals to falsely experience a sense of safety when they are in a passive state. It is likely that most injuries are perceived to be in some way the result of an act the victim performs which affects his or her environment. Thus, the person who is inactively standing under dangerous roof may feel secure, and may not be likely to expect or search for sources of danger. Other major types of activities being performed at the time of a roof fall fatality were equipment operation, manual loading of coal, and monitoring the trailing cable from the continuous miner.

Because roof bolters account for such a large portion of the fatalities (21 pct), an attempt was made to discover the phase of the bolting operation during which each bolter was killed. The fatality reports indicated that five bolters were installing timbers, posts or jacks; three were standing idle; two victims were marking the roof for bolts; two were drilling holes for bolts; two were removing temporary supports; two were walking; one was inserting a bolt; and one was scaling the roof. This suggests that the most dangerous phase of a bolter's job is the installation of temporary supports.

## DISCUSSION

The information obtained from miners and MSHA inspectors and presented in this report helps to better define the types of factors contributing to groundfall accidents, provides a valuable reference base, and offers direction for future research in this area.

A major strength of this report is that it is based on information obtained from people who work underground. They are an invaluable source of information about barriers to miners' prevention of groundfall accidents. These people are in a unique position to explain why miners sometimes neglect potentially hazardous roof problems, why they sometimes go beneath unsupported roof, how often

miners are going beneath unsupported roof, and what might be done to overcome barriers to miners' prevention of accidents. However, the answers given in the interviews do not totally reflect "truth" or "reality." There is a variety of cognitive limitations and motivational biases which shape the way people make sense of the world around them. In interpreting and understanding the data from this study, it is important to keep in mind that the miners interviewed were subject to a variety of such limitations and biases. However, given that there are no obvious reasons why the participants in this study would have wanted to provide distorted answers to the questions they were asked, and

given that they are the people whose decisions and actions most directly prevent or fail to prevent groundfall accidents, their assessment of the problem and potential solutions should most definitely be considered an informative and insightful source of information.

## BARRIERS TO ACCIDENT PREVENTION

The data collected for this study suggest that most people who work in underground coal mines agree that the factors listed in figure 1 are significant barriers to miners' prevention of groundfall accidents. The evidence supporting this assertion is reviewed below.

### Inability To Recognize Hazards

The reasons for an individual's inability to recognize groundfall hazards may be an attribute of the person or of the environment. Data supporting the importance of this set of factors comes from miners' responses to questions C.1, C.2, and C.4. Forty-four percent said better lighting would help miners avoid rock fall injuries to a large or very large degree. This implies that miners may often fail to recognize hazardous roof conditions because the illumination is not good enough for them to be able to detect the hazardous conditions. Fifty-six percent said less noise would help miners to a large or very large degree. This implies that there may often be too much noise for miners to hear sounds that could warn them that a hazardous roof condition exists. Sixty-eight percent said better training in the identification of roof hazards would help miners to a large or very large degree. This suggests that miners sometimes fail to recognize certain types of hazardous roof conditions because they are not aware that these roof conditions should be considered hazardous.

### Inability To Correct Hazards

Data supporting the importance of this set of factors comes from miners responses to reasons A.1 and A.6 and question C.6. Fifty-one percent agreed that one of the main reasons miners sometimes neglect correcting roof hazards is that they don't have the tools or materials with them that are needed to correct the roof problem. Thirty-seven percent agreed that one of the main reasons miners sometimes neglect to correct roof hazards is that they don't know how to correct roof problems. This suggests that miners sometimes fail to correct certain types of hazardous roof problems because they have never learned how to correct them. Sixty-nine percent said better training in proper methods of supporting the roof would help miners avoid rock fall injuries to a large or very large degree.

### Motivation To Search for Hazards

Data supporting the importance of this set of factors comes from miners' responses to reasons A.8 and A.7 and question C.3. Eighty-one percent agreed that one of the main reasons miners sometimes neglect to correct roof hazards is that they don't take enough time to look for roof problems. One reason miners might not take enough time to look for roof problems is that they do not realize how

dangerous roof problems are. In response to reason A.7, 68.4 pct agreed that one of the main reasons miners sometimes neglect to correct roof hazards is that they don't realize how dangerous roof problems are. Another reason miners might not take enough time to look for roof problems is that they may not think their supervisor wants them to devote much time to this activity. In response to question C.3, 56 pct indicated that "supervisors putting greater emphasis on correcting roof hazards" would help miners avoid rock fall injuries to a large or very large degree. However, in response to reason A.5, 89 pct *disagreed* with the statement, "One of the main reasons miners sometimes neglect to correct roof hazards is that they believe their supervisor thinks taking care of roof problems is unimportant." This suggests that some supervisors need to place greater emphasis on this activity.

### Motivation To Correct Hazards

Data supporting the importance of five types of factors within this category come from the miners' responses to reasons A.2, A.3, A.4, and A.7 and question C.3. Fifty-one percent agreed that one of the main reasons miners sometimes neglect to correct roof hazards is that they think it is someone else's responsibility to take care of roof problems. Forty-eight percent agreed that one of the main reasons miners sometimes neglect to correct roof hazards is that they don't want to risk getting hurt while fixing the roof. Fifty-eight percent agreed that one of the main reasons miners sometimes neglect to correct roof hazards is that they dislike doing the type of work necessary to correct the roof problem. Sixty-eight percent agreed that one of the main reasons miners sometimes neglect to correct roof hazards is that they don't realize how dangerous roof problems really are. Fifty-six percent indicated that "supervisors putting greater emphasis on correcting roof hazards" would help miners avoid rock fall injuries to a large or very large degree.

## WALKING BENEATH UNSUPPORTED ROOF

At least 50 pct of the miners agreed with each of five statements about why miners walk beneath unsupported roof. These responses suggest that most miners believe the main reasons why people walk beneath unsupported roof include: (1) They do it inadvertently; (2) they believe it is safe to do it; (3) they are trying to save time; (4) it takes too much effort to set temporary supports; and (5) it is considered an acceptable practice by coworkers. Eighty-eight percent of the miners said they believe that most miners do not walk beneath unsupported roof before looking at it carefully, suggesting that most miners who walk beneath unsupported roof are somewhat fearful of being struck by a roof fall.

The median of miners' estimates of the percentage of miners who go beneath unsupported roof during a typical month was 10 pct. Forty-four percent indicated that they believe someone goes beneath unsupported roof at least once per shift, and 25 pct indicated that they believe someone goes beneath unsupported roof at least once per week. Taken together, these estimates suggest (1) few miners are going beneath unsupported roof, but that (2) those who are going beneath unsupported roof are doing it rather often.

## **MINERS' AND INSPECTORS' RECOMMENDATIONS FOR PREVENTING GROUNDFAH ACCIDENTS**

When asked what should be done to reduce the number of rock fall accidents in the coal industry, miners frequently replied that better training was needed and that miners should somehow be motivated to inspect the roof more often. MSHA inspectors often said that the use of automated temporary roof support (ATRS) systems on bolters should be made mandatory; training should be improved; remote sensing devices should be used to check for gas at the face; continuous miner operators should be encouraged to report roof problems to bolters more often; and roof control plans need to be followed more closely.

The need for better training was mentioned frequently by both inspectors and miners. With regard to improving training, inspectors recommended the following: (1) Supplement classroom training with structured on-the-job training in roof control and the identification of groundfall hazards; (2) explain the theoretical principles of roof support in lay terms; (3) limit the size of training classes to encourage more discussion; and (4) increase miners' awareness of the consequences of roof falls by showing slides of roof fall accidents and relating the details of how people have been injured by them.

Most miners stated that the following proposed changes would significantly help miners avoid rock fall injuries: less

noise, supervisors putting greater emphasis on correcting roof hazards, better training in the identification of roof hazards, better training in proper methods of supporting the roof, reprimanding or penalizing those who repeatedly go beneath unsupported roof, better scaling of the roof, adding more support to bad areas of the roof, and better installation of roof bolts.

## **MINERS' EXPERIENCES WITH GROUNDFAH ACCIDENTS**

Unplanned rock falls in underground coal mines are a somewhat common event. Eighty-eight of the 143 miners interviewed reported that they had either been injured by or startled by a rock fall at least one time during the past year. Eighty-one percent of those who reported that they had been recently startled by large pieces of falling rock said that such an incident had happened more than once within the past year. The median for these incidents was three times. Sixty-five percent of the miners who reported that they had recently suffered an injury caused by a groundfall said they had been near the location of the rock fall for only a few minutes prior to the accident. This suggests that most rock fall accidents could be avoided if miners would always check the roof before beginning to work in a new area.

## APPENDIX.—ROOF FALL INTERVIEW GUIDE FOR MINERS

Interviewee:

Date:

Interviewer:

Name of mine:

Shift:

Section:

0000-0800

0800-1600

1600-2400

### 1. INTRODUCTION TO MINER QUESTIONNAIRE

Hello, my name is \_\_\_\_\_. I'm part of the group from the Bureau of Mines in Pittsburgh that is here to do some interviews with miners and mine management.

During this interview, I'm going to ask for your opinions about the causes of roof fall accidents, and what you think could be done to help prevent them.

Your participation is completely voluntary. You need not answer every question.

Anything that you do tell us will be held in strict confidence. By that I mean that nothing that you will say will be identified with you. Any report that is written will not identify any single miner's particular answer. For example, we might report that 90% of the miners at mine X believe roof falls are hard to predict.

Each miner will receive a summary of what the miners at his or her mine think about the causes and prevention of roof fall accidents. This summary will also provide information about what miners at other mines think about roof fall accidents. You may be curious about why we've chosen to talk to people from the mine where you work. Your mine is one of several mines that are part of our study. It was chosen because it met certain characteristics of size, type of mining technique, and location.

At this point, do you have any questions?

### 2. JOB HISTORY

Before beginning the questions about roof falls, I'd like to get some information about your experience as a miner.

2.1 What is your present job?

2.2 How long have you been on that job?

(If more than a month, go to 2.3.)

(If less than a month, go to 2.2a.)

2.2a Is this a permanent or temporary assignment? P T

If temporary, ask:

2.2b What is your regular job?

2.2c How long have you held that job?

2.3 How long have you worked in the section where you now work?

2.4 Altogether, how many years have you worked as a coal miner?

The new few questions are about your experience with performing roof control activities.

(If the miner is a bolter or bolter helper, skip to 2.7.)

2.5 During the past 6 months, did you help install any type of roof support?

Y N

(If yes, ask, "What types of roof support did you install?")

2.6 Have you ever worked as a roof bolter or bolter helper? Y N

(If yes, ask "How long were you a bolter or bolter helper?")

2.7 About how many days per week do you spend some time scaling the roof?

0 1 2 3 4 5

2.8 About how many days per week do you spend some time sounding the roof?

0 1 2 3 4 5

### 3. EXPERIENCE WITH ROOF FALLS

3.1.1 Within the past 2 yr, have you had a lost-time injury as a result of being struck by pieces of falling rock?

Y N (If no, go to 3.2.)

3.1.2 During the past year, have you been injured, bruised, or in any way hurt by pieces of rock falling from the roof or rib?

Y N (If no, go to section 3.A.)

3.2 How long ago did this happen?

3.3 What type of injury did you suffer?

3.4 Which of these best describes where you were when you were injured:

A. within 25 ft of the face

B. in a working section but not at the face

C. not in a working section (ask "Where were you?")

3.5 Did the rock fall in an area of roof that was supported or unsupported?

S U

If supported, ask, "What type of roof supports were being used at the place where the rock fell?"

3.6 What type of job were you doing on the day you were injured?

3.7 What were you doing at the moment the rock struck you?

3.8 On the day that the rock fell, about how many hours or minutes had you spent near the location of the rock fall before the fall actually occurred?

(Probes: most of the shift?

less than half the shift?

only a few minutes?)

3.9 During that time, did you notice anything unusual about the condition of the roof?

Y N

If yes, ask, "Please describe what you noticed that was unusual?"

3.10 Considering the week before the time that the rock fell, had the area where the rock fell been heavily traveled, lightly traveled, or not traveled at all?

H L N

3.11 Was anything unusual going on the day of the rock fall that might have distracted you, or caused you to pay less attention to the condition of the roof than usual?

3.12 Was there any noise coming from nearby tools or equipment at the time the rock fell?

Y N

(If yes, specify source and distance.)

3.13 Was there any source of light in the area where the rock fell other than your cap lamp?

Y N

(If yes, specify source and distance.)

3.14 Altogether, how many times during the past 6 months have you been close enough to large pieces of falling rock that they startled or surprised you?

(Go to section 4.)

### **Section 3.A—Experience With Roof Falls—No Injury**

3.1 Within the past year, have you been close enough to large pieces of falling rock that they startled or surprised you?

Y N

(If yes, go to 3.4.1.)

3.2 Within the past 6 months, has anyone told you that they came close to being hurt by falling rock?

Y N

(If no, go to section 4.)

3.3 What did they say about the rock fall?

(Go to section 4.)

3.4.1 How many times within the past year has this happened?

3.4.2 I'd like to ask you some questions about the most recent time you were surprised by falling rock. How long ago was the most recent time that this happened?

3.5 Which of these best describes where you were when the rock fell:

A. within 25 feet of the face

B. in a working section but not at the face

C. not in a working section (ask "Where were you?")

3.6 Did the rock fall in an area of roof that was supported or unsupported?

S U

If supported, ask, "What type of roof supports were being used at the place where the rock fell?"

3.7 What type of job were you doing on the day of the rock fall?

3.8 What were you doing at the moment the rock fell?

3.9 On the day that the rock fell, about how many hours or minutes had you spent near the location of the rock fall before the fall actually occurred?

(Probes: most of the shift?  
less than half the shift?  
only a few minutes?)

3.10 During that time, did you notice that anything was unusual about the condition of the roof?

Y N

If yes, ask, "Please describe what you noticed that was unusual."

3.11 Considering the week before the time that the rock fell, had the area where the rock fell been heavily traveled, lightly traveled, or not traveled at all?

H L N

3.12 Was anything unusual going on the day of the rock fall that might have distracted you, or caused you to pay less attention to the condition of the roof than usual?

3.13 Was there any noise coming from nearby tools or equipment at the time the rock fell?

Y N

(If yes, specify source and distance.)

3.14 Was there any source of light in the area where the rock fell other than your cap lamp?

Y N

(If yes, specify source and distance.)

#### 4. NONRESPONSE TO POSSIBLE ROOF HAZARDS

The next few questions are about why miners sometimes neglect to correct hazardous roof conditions. At one time or another, most miners have seen areas of the roof that look like they may not be entirely safe, but for some reason, do not do anything about it.

What are the major reasons why miners sometimes fail to do anything about potential roof hazards?

I'm going to read a list of reasons why miners might not do anything about potentially hazardous roof conditions. As I read each one, I'd like you to tell me the extent to which you agree or disagree that it explains why miners sometimes fail to respond. Please use the numbers on this response card for your answers. As you can see, the answers on this card range from 1, for strongly agree, to 6, for strongly disagree.

##### RESPONSE CARD

1. strongly agree
2. agree
3. slightly agree
4. slightly disagree
5. disagree
6. strongly disagree

(EXAMPLE: The fishing around here is good.)

One of the main reasons miners sometimes neglect to correct roof hazards is that—

4.1 they don't have the tools or materials with them that are needed to fix the roof problem.

- 4.2 they think it is someone else's responsibility to take care of roof problems.
- 4.3 they don't want to risk getting hurt while fixing the roof.
- 4.4 they dislike doing the type of work necessary to correct the roof problem.
- 4.5 they believe their supervisor thinks that taking care of roof problems is unimportant.
- 4.6 they don't know how to correct roof problems.
- 4.7 they don't realize how dangerous roof problems are.
- 4.8 they don't take enough time to look for roof problems.

## 5. WORKING BENEATH UNSUPPORTED ROOF

The next set of questions are about working beneath unsupported roof. The only legally permissible reason for going beneath unsupported roof is to set temporary supports before bolting. However, miners sometimes go beneath unsupported roof for reasons *other than to set temporary supports*. We are interested in knowing more about these other reasons. So, please base your answers to these next few questions on the times when miners go beneath unsupported roof for reasons *other than to set temporary supports*. I'm going to read several statements about going beneath unsupported roof. Using the response card, I'd like you to tell me the extent to which you agree or disagree with each of these statements.

One of the main reasons miners sometimes walk beneath unsupported roof is that—

- 5.1 they do not realize they have gone beyond the edge of roof that is properly supported, and do not intend to do so.
- 5.2 they do not believe it is unsafe to do so.
- 5.3 they are trying to save time.
- 5.4 it takes too much effort to set temporary supports.
- 5.5 they have often seen other people do it.
- 5.6 most miners do not walk beneath unsupported roof before looking at it carefully.

### RESPONSE CARD

- 1. strongly agree
- 2. agree
- 3. slightly agree
- 4. slightly disagree
- 5. disagree
- 6. strongly disagree

5.8 During a typical month, what percentage of miners who work at the face go beneath unsupported roof for reasons other than to set temporary supports?

5.9 Considering a typical crew of miners who work at the face, how often does someone go beneath unsupported roof for reasons other than to set temporary supports?

(once a shift? week? month?)

## 6. TECHNIQUES FOR REDUCING ROOF FALL ACCIDENTS

16887 285

The next few questions are about things that could be done to reduce roof fall accidents.

What do you think should be done to reduce the number of roof fall accidents in the coal industry?

I'm going to read a list of things that might be done to help miners avoid roof fall injuries. Using this new response card, I'd like you to rate the degree to which each of the following would help miners to avoid roof fall injuries. As you can see, the answers on this card range from 1, a very small degree, to 6, a very large degree.

To what degree would \_\_\_\_\_ help miners avoid rock fall injuries?

6.1 better lighting

(If miner replies with 5 or 6, ask, "How could the lighting be improved?")

6.2 less noise

6.3 supervisors putting greater emphasis on correcting roof hazards

6.4 better training in the identification of roof hazards

6.5 better training in proper methods to support the roof

6.6 reprimanding or penalizing those who repeatedly go beneath unsupported roof

6.7 better scaling of the roof

6.8 adding more support to bad areas of the roof

6.9 better installation of roof bolts

#### RESPONSE CARD

1. a very small degree
2. a small degree
3. a somewhat small degree
4. a somewhat large degree
5. a large degree
6. a very large degree

#### 7. DEMOGRAPHICS

The last three questions concern your age, marital status, and dependents.

What is your age?

Do you have any children? Y N

Are you currently married? Y N

Thank you for helping us with this study.











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